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UV Degradation Effects: Terrestrial versus Space Environment

Katie Gamaunt, Krysta Moser, Alexander Souvall and JR Dennison
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Materials Tested

Glasses	Polymers
• Sodium Glass	• Low Density Polyethylene (LDPE)
• Borosilicate Glass	• Polyimide (PI)
• Quartz	• Polyethylene Terephthalate (PET)
• Fused Silica	• Polycarbonate (PC)

Light Interactions

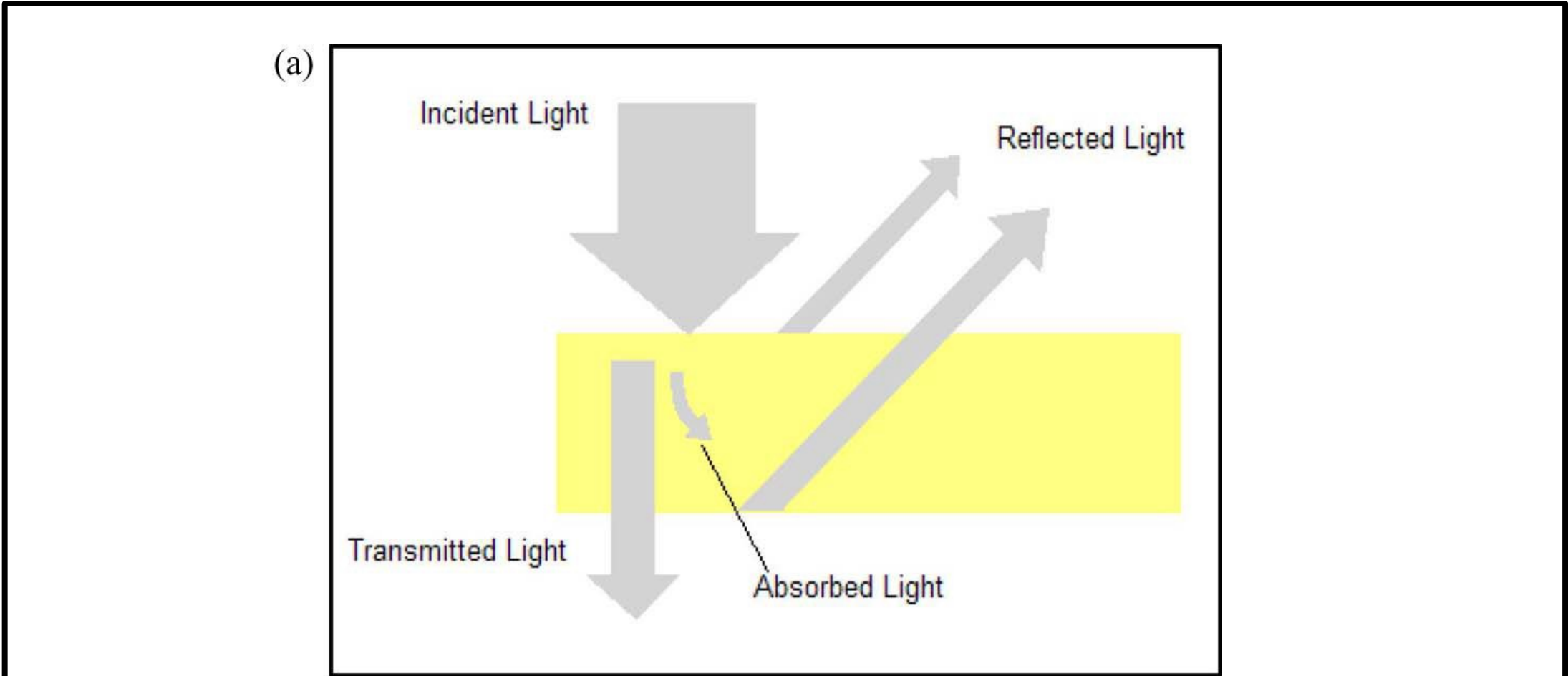
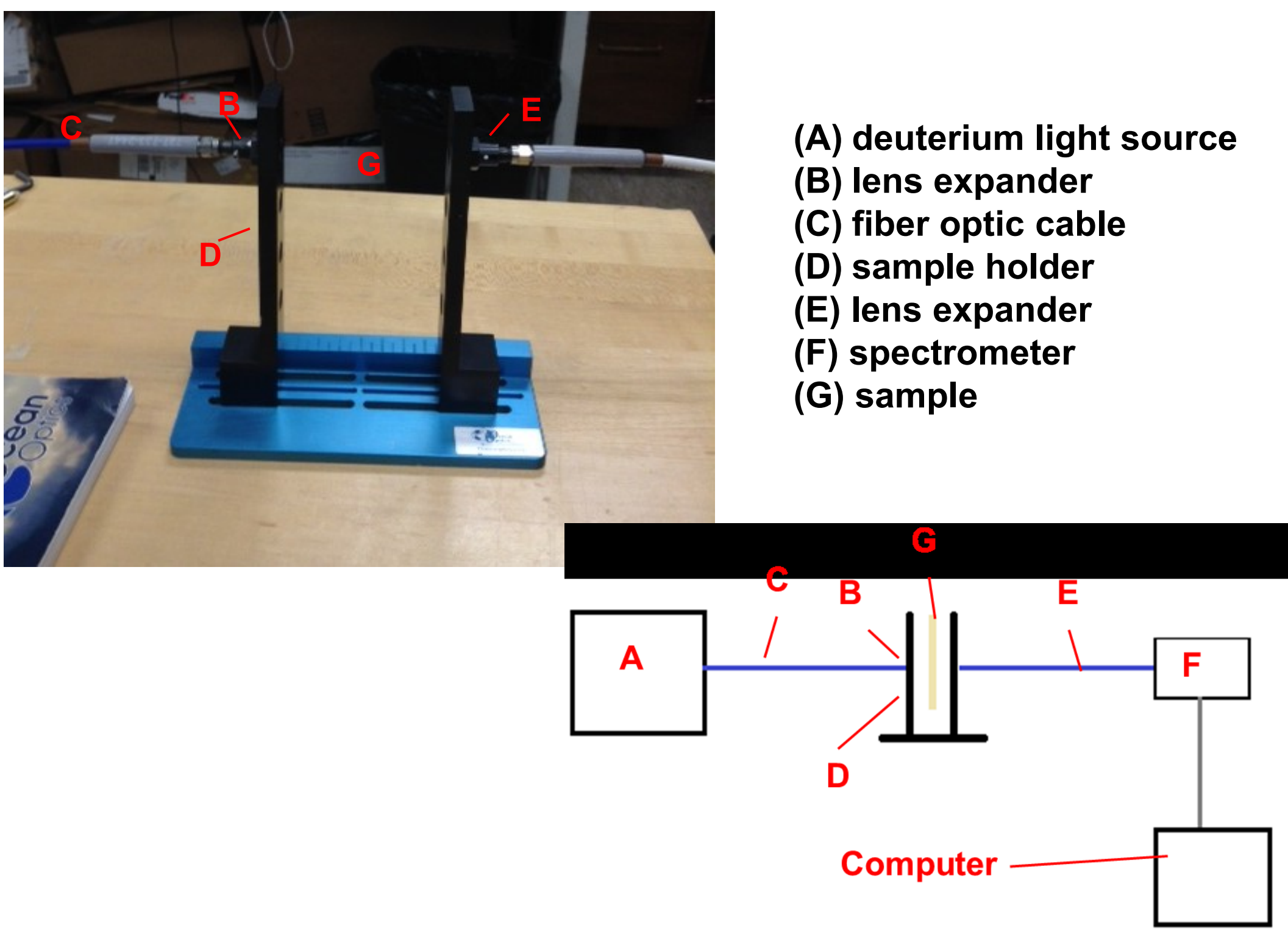


Fig. 1. As light hits a material some of the light goes through the material (transmitted) some is absorbed by the material and the rest is reflected back. There are two places for the light to be reflected at the point the incident light hits or at the back of the material.

Experimental Setup



- The deuterium light source (A) is connected to a lens expander (B) via a fiber optic cable (C) mounted in a sample holder (D).
- A lens expander (E) collects light, which is funneled to a spectrometer (HR 4900 from Ocean Optics) (F).
- The sample (G) is then placed between the two beam expanders.
- The more distance between lens expanders, the less saturation occurs.

Overview

UV light has shorter wavelengths (100 nm – 400 nm) which in turn means that it has more energy. The more energy it has the more electrons can be excited to create ions that can have detrimental effects on materials. This project looked at the effects that the atmosphere has in regards to blocking UV radiation and thus, slowing down the UV degradation process. Materials such as quartz, borosilicate glass, sodium glasses, polyethylene, polyimide, and polyethylene terephthalate polymers were exposed to radiation from a focused high intensity deuterium lamp source, which generates radiation in the UVA (315 nm – 400 nm) and UVB (280 nm – 315 nm) spectrum. The materials' UV/VIS/NIR (~200 nm to 1700 nm) transmission spectra were examined with a fiber optic spectrometer.

Polycarbonate (Terrestrial) Transmission

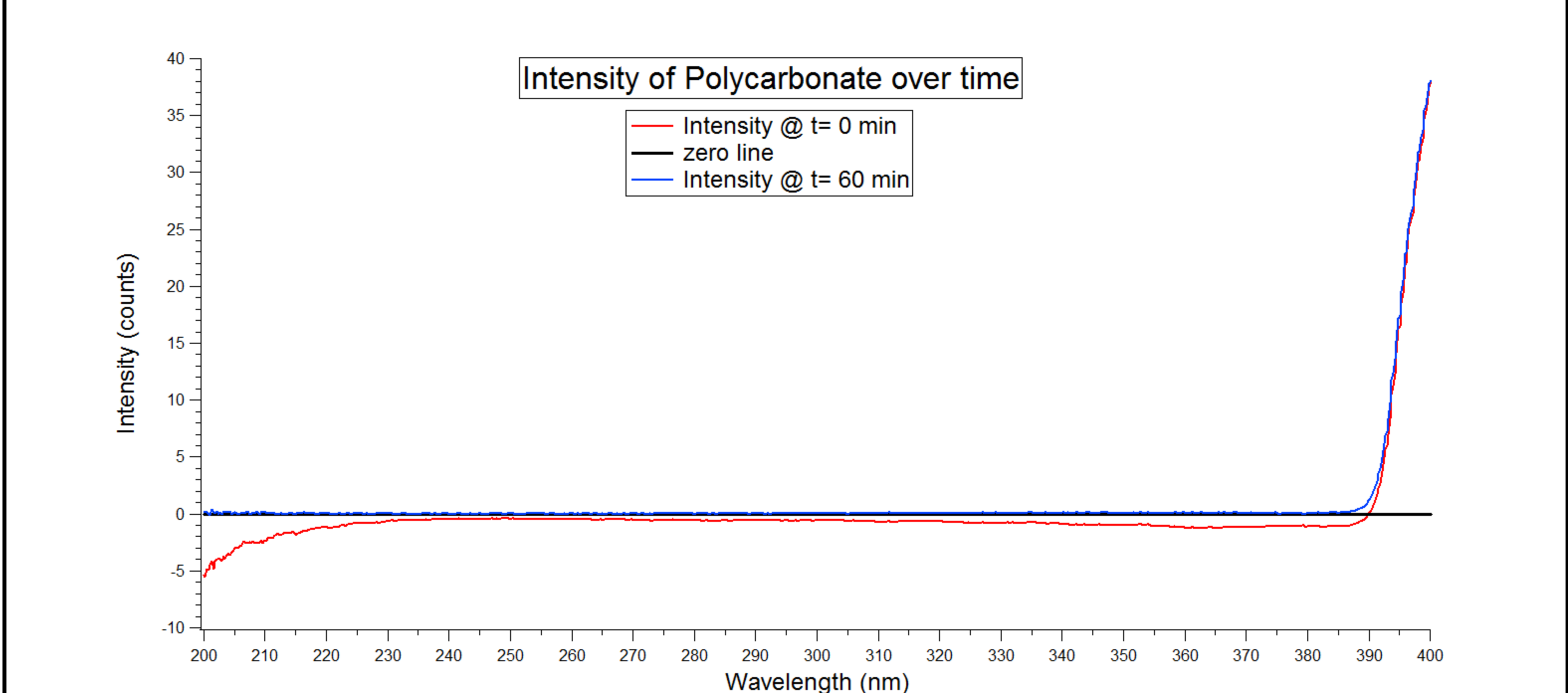


Fig. 2: The raw data for the intensity at t=0 min and t=60 min.

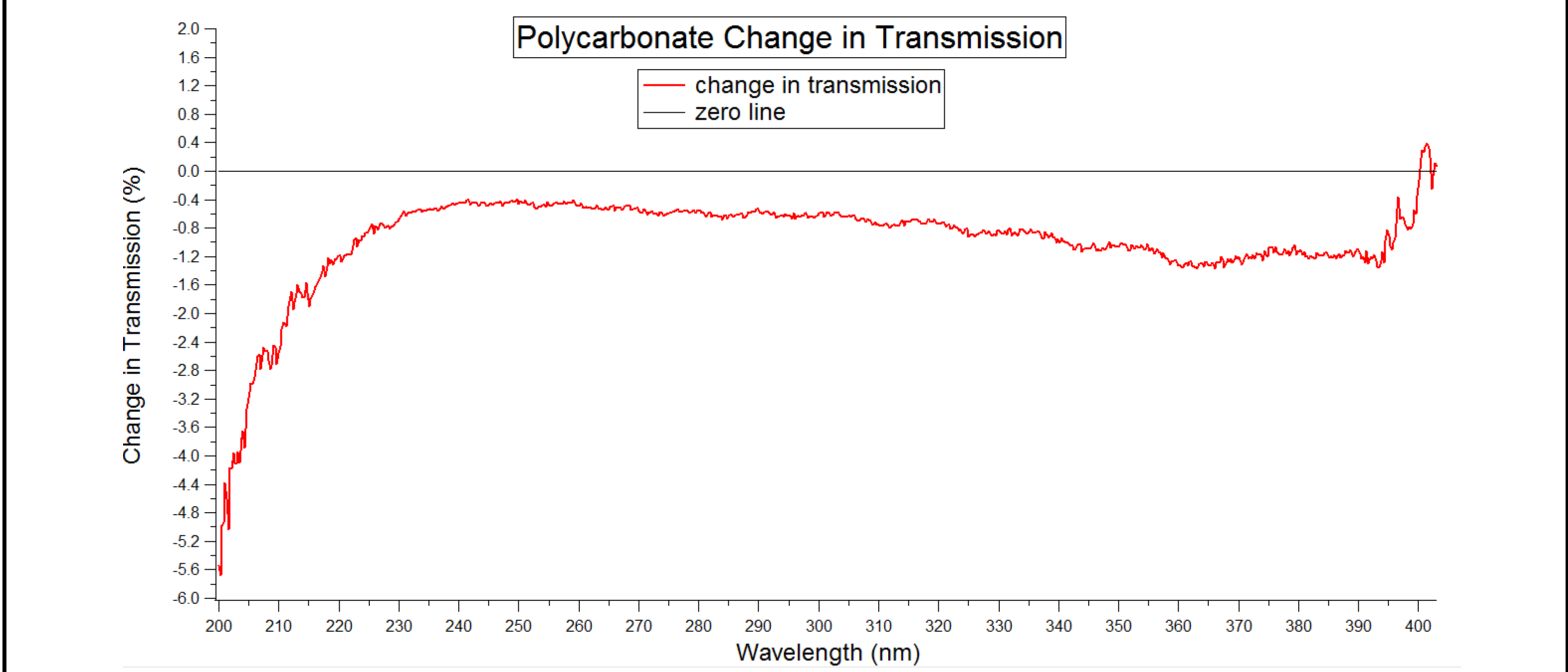


Fig. 3: The change in percent transmission for Polycarbonate in atmosphere and at pressure.

Calculations

Intensity Spectra

Background NO UV = B Background with UV = B_{uv}

Polycarbonate (t=0 min) = I_0 Polycarbonate (t=60 min) = I_{60}

Transmission @ t=0 min Transmission @ t=60 min

$$T_i = \frac{I_0 - B}{B_{uv} - B}$$
$$T_f = \frac{I_{60} - B}{B_{uv} - B}$$

Change in Transmissic

$$\Delta T = T_f - T_i$$

- For these calculations the data sets were imported into Excel.
- To find the initial amount of transmission the intensity of the UV source through the polycarbonate just as it was turned on was corrected by the intensity of the background radiation with no UV.
- That was then divided by the background with UV corrected by the intensity of the background with no UV (see Fig. 2).
- For the final transmission, it is the same except using the data from the polycarbonate after being radiated for 60 minutes (see Fig. 2).
- The initial transmission subtracted from the final transmission yields the change in transmission (see Fig. 3).

Conclusion

Focusing on the wavelengths that are in the UV range, it can be seen from Fig. 3 that there was a change in transmission. Over the 60 minute radiation period the polycarbonates percent change in transmission decreased the most at about 200 nm. Overall the transmission decreased in the UV wavelength range. These changes would be more apparent if the sample was exposed to the deuterium source for a longer amount of time. Using the specs from Ocean Optics, the light source is about 0.6% of AM0 Solar Intensity. When equivocating the exposure time to that of the sun, it would only take 20 seconds in the sun to achieve this amount of change.

Future Work

In the future, analysis of the effect of being exposed to the radiation will be complete and to the pressure atmospheric gases puts on a material. A particularly severe effect might result from atmospheric oxygen exposed to intense UV radiation which can produce atomic oxygen. It would be ideal to have the materials be radiated for long periods of time in order to be more realistic to the mission time of different satellites.

Acknowledgments and References

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Samples courtesy of Material Physics Group.

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